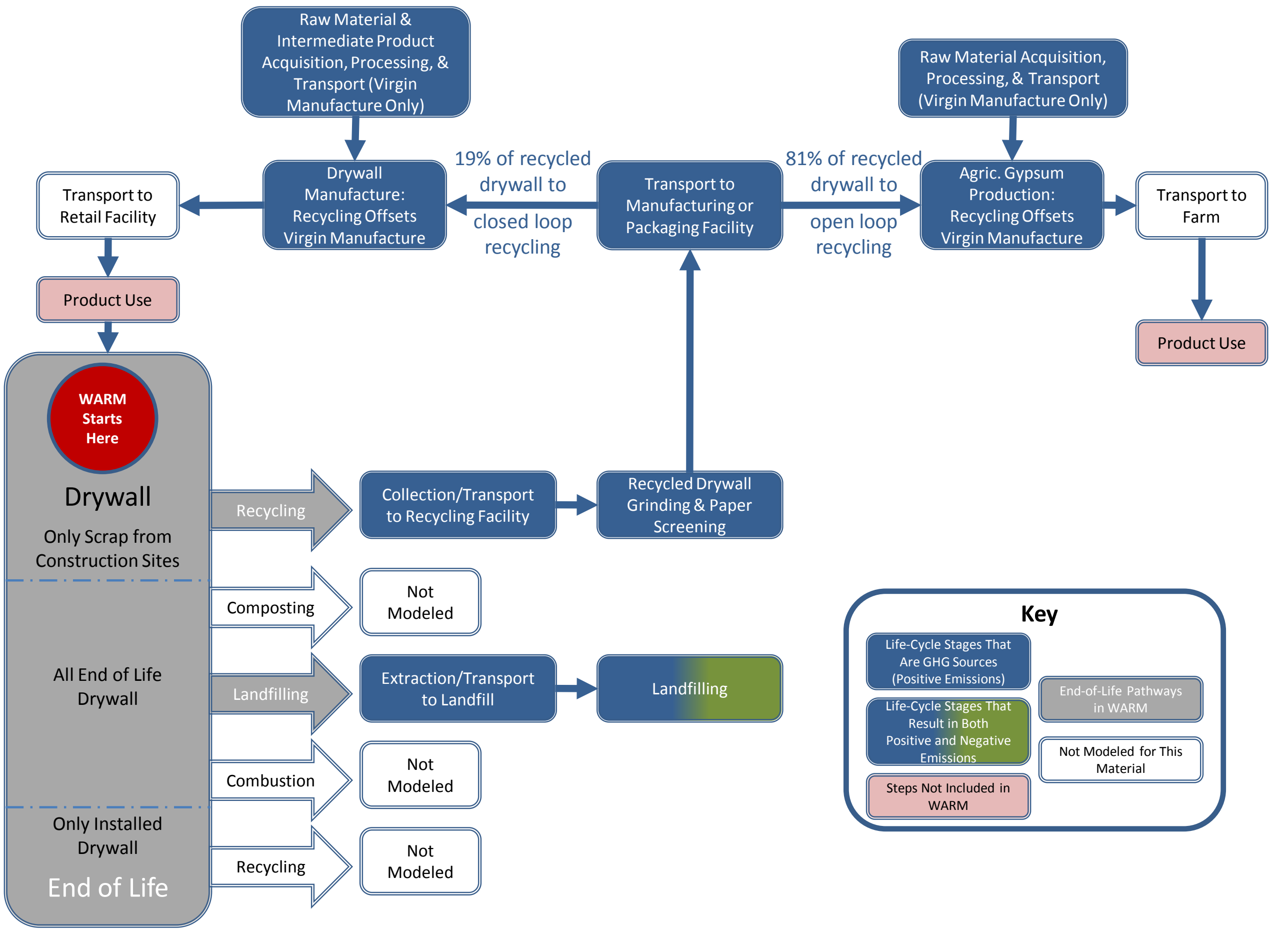
DRYWALL

1. INTRODUCTION TO WARM AND DRYWALL

This chapter describes the methodology used in EPA's Waste Reduction Model (WARM) to estimate streamlined life-cycle greenhouse gas (GHG) emission factors for drywall beginning at the waste generation reference point.[1] The WARM GHG emission factors are used to compare the net emissions associated with drywall in the following three waste management alternatives: source reduction, recycling, and landfilling. Exhibit 1 shows the general outline of materials management pathways for drywall in WARM. For background information on the general purpose and function of WARM emission factors, see the Introduction & Overview chapter. For more information on Source Reduction, Recycling, and Landfilling, see the chapters devoted to those processes. WARM also allows users to calculate results in terms of energy, rather than GHGs. The energy results are calculated using the same methodology described here but with slight adjustments, as explained in the Energy Impacts chapter.

Exhibit 1: Life Cycle of Drywall in WARM



Drywall, also known as wallboard, gypsum board or plaster board, is manufactured from gypsum plaster and a paper covering. Exhibit 2 presents the sources of drywall entering the waste stream.

[1] EPA would like to thank Rik Master of USG Corporation for his efforts at improving these estimates.

Exhibit 2: Composition of the Drywall Waste Stream

Source of Waste Drywall	% of Total
New Construction	64%
Demolition	14%
Manufacturing	12%
Renovation	10%

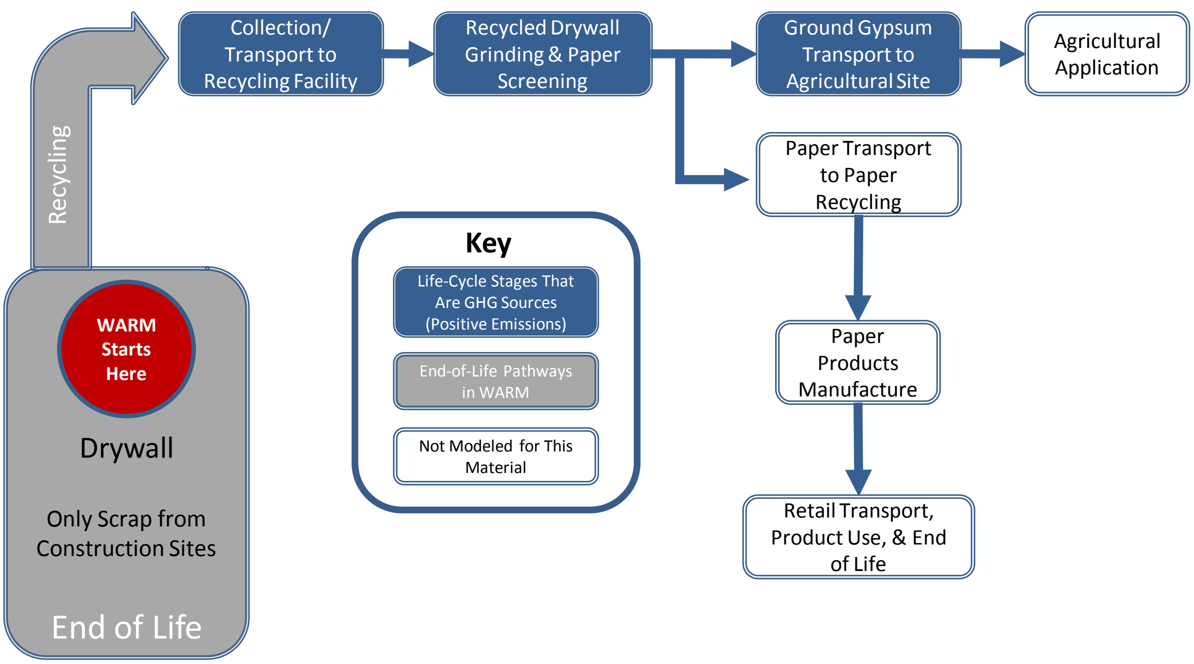
Source: CIWMB (2009b).

There are several different types of drywall products, including fire-resistant types (generally known as Type X drywall), water-resistant types and others. Additionally, drywall can be produced in a range of thicknesses. Our analysis examines the life-cycle emissions of the most common type of drywall, half-inch-thick regular gypsum board.

Most drywall is currently disposed of in landfills (Master, 2009). This disposal pathway can be problematic; if water is admitted to the landfill, under certain conditions the drywall may produce hydrogen sulfide gas. Incineration can produce sulfur dioxide gas, and is banned in some states (CIWMB, 2009b). Drywall is sometimes accepted at composting facilities, but it is used as an additive to compost, rather than a true compost input (please see section 4.3). For this reason, WARM does not include a composting emission factor for drywall. However, users interested in the GHG implications of sending drywall to a composting facility can use the recycling factor as a proxy (again, see section 4.3).

Drywall, however, is sometimes recycled into agricultural products, new drywall, a component of cement and some other uses. Sometimes the gypsum and paper are disposed of together, but they are also sometimes separated out during the recycling process, creating a somewhat more complicated life-cycle pathway (refer to Exhibit 1 for the primary lifecycle pathways of the gypsum and paper used in drywall). Recycling drywall is an open-loop process, meaning that components are recycled into secondary materials such as agricultural amendments and paper products. Building on Exhibit 1, a more detailed flow diagram showing the open-loop recycling pathways of drywall is provided in Exhibit 3.

Exhibit 3: Detailed Recycling Flows for Drywall in WARM



2. LIFECYCLE ASSESSMENT AND EMISSION FACTOR RESULTS

The streamlined life-cycle GHG analysis in WARM focuses on the waste generation point, or the moment a material is discarded, as the reference point and only considers upstream GHG emissions when the production of new materials is affected by materials management decisions.[2] Recycling and Source Reduction are the two materials management options that impact the upstream production of materials and consequently are the only management options that include upstream GHG emissions. For more information on evaluating upstream emissions, see the chapters on Recycling and Source Reduction.

WARM does not consider composting or combustion for drywall. As Exhibit 4 illustrates, the GHG sources and sinks relevant to drywall in this analysis are contained in all three sections of the life cycle assessment: raw materials acquisition and manufacturing (RMAM), changes in forest or soil carbon storage, and materials management.

Exhibit 4: Drywall GHG Sources and Sinks from Relevant Materials Management Pathways

Materials Management Strategies for Drywall	GHG Sources and Sinks Relevant to Drywall		
	Raw Materials Acquisition and Manufacturing	**Changes in Forest or Soil Carbon Storage**	**End of Life**
Source Reduction	**Offsets** • Avoided raw material acquisition of gypsum • Avoided manufacturing of wallboard, including paper facing • Avoided transportation of raw gypsum	NA	NA
Recycling	**Emissions** • Transport of recycled materials to drywall recycling facility , and then to drywall manufacturing facility and retail site • Recycled manufacture process energy **Offsets** • Avoided gypsum extraction and initial processing • Avoided manufacturing of wallboard • Avoided transport of virgin gypsum to drywall manufacturing facility and site	NA	**Emissions** • Drywall extraction • Grinding of drywall • Transport to recycling facility
Composting	Not modeled in WARM		
Combustion	Not modeled in WARM		
Landfilling	NA	**Offsets** • Landfill carbon storage by paper facing	**Emissions** • Transport to construction and demolition landfill • Landfilling machinery • Landfill methane emissions from paper facing

NA = Not applicable.

WARM analyzes all of the GHG sources and sinks outlined in Exhibit 4 and calculates net GHG emissions per short ton of drywall inputs. For more detailed methodology on emission factors, please see sections 4.1 through 4.5. Exhibit 5 outlines the net GHG emissions for drywall under each materials management option.

[2] The analysis is streamlined in the sense that it examines GHG emissions only and is not a comprehensive environmental analysis of all environmental impacts from municipal solid waste management options.

Exhibit 5: Net Emissions for Drywall under Each Materials Management Option ($MTCO_2E$/Short Ton)

Material/ Product	Net Source Reduction (Reuse) Emissions for Current Mix of Inputs	Net Recycling Emissions	Net Composting Emissions	Net Combustion Emissions	Net Landfilling Emissions
Drywall	-0.22	0.03	0.03	NA	0.13

Note: Negative values denote net GHG emission reductions or carbon storage from a materials management practice.
NA = Not applicable.

3. RAW MATERIALS ACQUISITION AND MANUFACTURING

GHG emissions associated with raw materials acquisition and manufacturing are (1) GHG emissions from energy used during the acquisition and manufacturing processes, (2) GHG emissions from energy used to transport raw materials, and (3) non-energy GHG emissions resulting from manufacturing processes.[3] For drywall, process energy GHG emissions result from acquiring the virgin gypsum used in manufacture, as well as the manufacturing processes used to prepare the stucco and paper facings, and to produce the actual wallboards. Transportation emissions are generated from transporting raw materials to the drywall manufacturing facility. Due to the nature of the processes and materials used to manufacture drywall, there are no non-energy process emissions.

Gypsum products use a combination of virgin, recycled and synthetic gypsum. Virgin gypsum is synonymous with mined gypsum, recycled gypsum comes mainly from drywall, and synthetic gypsum is the product of various industrial processes, mainly from pollution-control equipment at coal-fired power plants. The proportion of each type of gypsum used varies by product and by manufacturer. However, virgin gypsum comprises the vast majority (85 percent) of “new” (non-recycled) gypsum consumption in the United States (Olson, 2000). The contribution of recycled gypsum is not known, but is likely much smaller than new gypsum, given the fact that most drywall appears to be landfilled at present.

To manufacture drywall, the gypsum is first heated and partially dehydrated (calcined), resulting in a material known as stucco. Next, the stucco is mixed with water and some additives to create a gypsum slurry. This slurry is spread onto a layer of facing paper, then covered by another layer of facing paper, so that the slurry is sandwiched between two layers of paper. When the slurry has hardened, the resulting boards are cut to the desired length, sent to a drying kiln, and then readied for shipment.

Installed drywall also requires the use of finishing products (e.g., nails and joints). While these products are closely linked to the use of drywall, they represent a relatively small portion of installed drywall. EPA did not have sufficient data to assess the impacts these components would have on the different end-of-life pathways, and therefore excluded these products from the analysis.

The RMAM calculation in WARM also incorporates “retail transportation,” which includes the average truck, rail, water and other-modes transportation emissions required to transport drywall from the manufacturing facility to the retail/distribution point, which may be the customer or a variety of other establishments (e.g., warehouse, distribution center, wholesale outlet). The energy and GHG emissions from retail transportation are presented in Exhibit 6. Transportation emissions from the retail point to the consumer are not included. The miles traveled fuel-specific information is obtained from the 2007 *U.S. Census Commodity Flow Survey* (BTS, 2007) and greenhouse gas emissions from the Management of Selected Materials (EPA, 1998).

Exhibit 6: Retail Transportation Energy Use and GHG Emissions

Material/Product	Average Miles per Shipment	Retail Transportation Energy per Short Ton of Product (Million Btu)	Retail Transportation Emissions ($MTCO_2E$/ Short Ton)
Drywall	388	0.42	0.03

[3] Process non-energy GHG emissions are emissions that occur during the manufacture of certain materials and are not associated with energy consumption.

4. MATERIALS MANAGEMENT METHODOLOGIES

WARM evaluates GHG sources and sinks from source reduction, recycling and landfilling of drywall. Exhibit 7 provides the net GHG emissions per short ton of drywall for each of these materials management pathways. Source reduction avoids GHG emissions because it offsets emissions from manufacturing processes and transportation of raw materials. Landfilling results in GHG emissions from the transport of drywall to the landfill, operation of landfill equipment and production of landfill methane. Recycling drywall into new drywall or using it for agricultural purposes results in positive net emissions, but fewer emissions than would be obtained from landfilling the material. More details on the methodologies for developing these emission factors are provided in sections 4.1 through 4.5.

EPA used data on drywall manufacturing from the Athena Sustainable Materials Institute (Venta, 1997), which assumes that drywall is manufactured with 85 percent virgin gypsum, 6 percent synthetic gypsum, 5 percent gypsum recycled from manufacturing waste (internal recycling) and 4 percent recycled gypsum from construction sites (Venta, 1997, Table 9.3). Because we were unable to disaggregate the energy data for each source of gypsum, our 100 percent “virgin” drywall estimates in fact represent this composition. However, since most drywall likely contains at least some synthetic and/or recycled gypsum, this composition likely approximates an upper bound for virgin gypsum in drywall. Also, the paper facing used in drywall is made from recycled paper. The “virgin” drywall estimates therefore reflect the use of recycled paper rather than virgin paper. The “current mix” of drywall production reflects these same percentages.

4.1 SOURCE REDUCTION

Reducing the amount of drywall wasted at construction sites, or the amount of drywall and other wall finishing products needed, results in emission reductions. The benefits of source-reducing drywall come primarily from avoided emissions from the manufacturing process, and also from avoided transportation emissions. Avoided raw material acquisition presents some small additional savings. The avoided emissions are summarized in Exhibit 7. For more information on this topic, please see the chapter on Source Reduction.

Exhibit 7: Source Reduction Emission Factors for Drywall ($MTCO_2E$/Short Ton)

Material/Product	Raw Material Acquisition and Manufacturing for Current Mix of Inputs[a]	Raw Material Acquisition and Manufacturing for 100% Virgin Inputs	Forest Carbon Storage for Current Mix of Inputs	Forest Carbon Storage for 100% Virgin Inputs	Net Emissions for Current Mix of Inputs	Net Emissions for 100% Virgin Inputs
Drywall	-0.22	-0.22	NA	NA	-0.22	-0.22

Note: Negative values denote net GHG emission reductions or carbon storage from a materials management practice.
[a]: For this material, information on the share of recycled inputs used in production is unavailable or is not a common practice; EPA assumes that the current mix is comprised of 100% virgin inputs. Consequently, the source reduction benefits of both the “current mix of inputs” and “100% virgin inputs” are the same.
NA = Not applicable.

Post-consumer emissions are the emissions associated with materials management pathways that could occur at end of life. When source-reducing drywall, there are no post-consumer emissions because production of the material is avoided in the first place, and the avoided drywall never becomes post-consumer. Forest carbon storage is not applicable to drywall, and thus does not contribute to the source reduction emission factor.

4.1.1 Developing the Emission Factor for Source Reduction of Drywall

The approach and data sources used to calculate the emission factor for source reduction of drywall are summarized in the following paragraphs for each of the three categories of GHG emissions: process energy (pre-combustion and combustion), transportation energy and process non-energy emissions. Exhibit 8 shows the results for each component and the total GHG emission factors for source reduction of drywall.

Exhibit 8: Raw Material Acquisition and Manufacturing Emission Factor for Virgin Production of Drywall ($MTCO_2E$/Short Ton)

(a) Material/Product	(b) Process Energy	(c) Transportation Energy	(d) Process Non-Energy	(e) Net Emissions (e = b + c + d)
Drywall	0.18	0.04	–	0.22

Note: Negative values denote net GHG emission reductions or carbon storage from a materials management practice.
– = Zero emissions.

Avoided Process Energy. Process energy GHG emissions result from the direct combustion of fossil fuels used to extract raw materials and to manufacture the stucco, the paper facing and the drywall boards themselves. Process energy also includes the upstream emissions associated with the production of fuels and electricity (i.e., "pre-combustion" energy).[4] EPA obtained data on raw material extraction, and drywall and paper manufacturing from Venta (1997). While these data are several years old, they represent the most complete dataset available at the time these emissions factors were developed.

During the expert review process, EPA received feedback that indicated that, while our overall estimate for energy needs for wallboard production were reasonable, the breakdown of the estimates across the various production stages were not quite consistent with current industry experience. The discrepancies are possibly due to process changes since the Venta (1997) report was published, and to production differences in Canada versus the United States. EPA was unable to obtain more specific estimates of energy needs, as the data were proprietary, and therefore scaled the Venta (1997) energy estimates so that each stage contributed similar proportional amounts of energy usage as the more recent industry estimates. When excluding wallboard distribution (which is included elsewhere in the calculations), the energy breakdown of the drywall production stage is approximately:

- Raw material creation—13 percent
- Raw material transportation—3 percent
- Wallboard manufacturing—85 percent.[5]

Because the Venta (1997) estimates do not include the pre-combustion energy of the fuels, EPA added pre-combustion values based on pre-combustion estimates by fuel types cited in FAL (2007). Total process energy GHG emissions are calculated as the sum of GHG emissions, including both CO_2 and CH_4, from all of the fuel types used in the production of one ton of drywall. Results of these calculations are provided in Exhibit 9.

Exhibit 9: Process Energy GHG Emissions Calculations for Virgin Production of Drywall

Material/Product	Process Energy per Short Ton Made from Virgin Inputs (Million Btu)	Process Energy GHG Emissions ($MTCO_2E$/Short Ton)
Drywall	3.08	0.18

Avoided Transportation Energy. Transportation energy emissions occur when fossil fuels are used to transport raw materials, intermediate products for drywall production and the finished drywall to the retail location. Transportation energy also includes the upstream emissions associated with the production of fuels and electricity (i.e., "pre-combustion" energy).

While the U.S. Census Bureau (2004) provides transportation data on the transport of raw gypsum, WARM uses transportation data from use estimates provided by R. Master (personal communication, February 26, 2010) for raw gypsum because, among the estimates currently available, these appear to be the most recent and most relevant to the United States. EPA obtained transportation data on finished products from the Census Bureau (2004). The related GHG emissions are provided in Exhibit 10.

[4] Pre-combustion emissions refer to the GHG emissions that are produced by extracting, transporting and processing fuels that are in turn consumed in the manufacture of products and materials.
[5] Derived from Master (2010).

Exhibit 10: Transportation Energy Emissions Calculations for Virgin Production of Drywall

Material/Product	Transportation Energy per Short Ton Made from Virgin Inputs (Million Btu)	Transportation Energy GHG Emissions ($MTCO_2E$/Short Ton)
Drywall	0.10	0.01

Note: The transportation energy and emissions in this exhibit do not include retail transportation, which is presented separately in Exhibit 6.

4.2 RECYCLING

When a material is recycled, it is used in place of virgin inputs in the manufacturing process, rather than being disposed of and managed as waste. Drywall is modeled as being recycled in a semi-open loop, since some drywall is recycled back into drywall (closed loop), and some is recycled into agricultural gypsum (open loop). This section describes the development of the recycling emission factor for drywall, which is shown in the final column of Exhibit 11. For more information about this topic, please refer to the Recycling chapter.

Exhibit 11: Recycling Emission Factor for Drywall ($MTCO_2E$/Short Ton)

Material/ Product	Raw Material Acquisition and Manufacturing (Current Mix of Inputs)	Materials Management Emissions	Recycled Input Credit[a] Process Energy	Recycled Input Credit[a] – Transport-ation Energy	Recycled Input Credit[a] – Process Non-Energy	Forest Carbon Storage	Net Emissions (Post-Consumer)
Drywall	–	–	0.01	0.03	–	–	0.03

NA = Not applicable.
– = Zero emissions.

4.2.1 Developing the Emission Factor for Recycling of Drywall

EPA calculates the GHG benefits of recycling drywall by comparing the difference between the emissions associated with manufacturing drywall and agricultural gypsum from virgin materials versus manufacturing them using recycled drywall.

While a handful of U.S. recyclers now accept post-construction drywall waste, almost all recycled drywall still comes from new drywall scrap (i.e., clean, uninstalled drywall scraps from construction sites). Concerns over lead and asbestos contamination can make recyclers wary of recycling drywall from renovation and demolition, and make some states reluctant to issue permits to allow this recycling (Manning, 2009). Therefore, the recycling estimates in WARM represent the recycling of new drywall scrap from construction sites.

To recycle drywall, the drywall is first ground, resulting in about 93 percent gypsum powder, 6.8 percent shredded paper, and 0.2 percent waste (which is landfilled), by weight (WRAP, 2008). The paper can be left in, if it is used as an agricultural amendment, or screened out and recycled.

Most recycled drywall is used for a variety of agricultural purposes. For example, the gypsum can be used as a soil conditioner, as it helps increase soil water infiltration and adds calcium and sulfur to the soil. The paper backing, meanwhile, can be recovered and used as animal bedding. Drywall is also recycled back into new wallboard and is possibly used in concrete manufacture. WARM assumes that 19 percent of recycled drywall is recycled into new drywall (closed-loop recycling), and 81 percent is recycled for agricultural purposes (open-loop recycling) (derived from Master, 2009) as illustrated in Exhibit 12. There is conflicting evidence about the extent to which recycled gypsum is used in cement manufacture. Due to a lack of information, EPA has not included cement manufacture as a recycling pathway for drywall in WARM. However, as the recycled gypsum would likely displace virgin gypsum, savings from avoided raw material extraction and transportation and avoided landfilling emissions would likely be similar to those raw material and landfilling savings experienced when recycling gypsum into agricultural products and new drywall.

Exhibit 12: Assumed End-Uses of Recycled Drywall

	% of Recycled Drywall Going to this End Use
Drywall	19%
Agricultural Uses	81%

Source: Derived from Master (2009).

Since wallboard facing is always made from recycled paper, recycling the drywall paper facing into new drywall paper facing does *not* displace virgin paper production. Rather, it represents another source of recycled paper for the drywall manufacturing process. The calculations therefore focus on recycling of the gypsum. In reality, some of the recycled gypsum used for agricultural purposes may contain paper, which may eventually be applied to fields. While this process may result in some form of soil carbon sequestration, EPA is not able to accurately estimate the sequestration values and therefore did not include this in the analysis.

To calculate the recycling factor for drywall, EPA followed five steps, which are described in detail.

Step 1: *Calculate emissions from virgin production of one short ton of drywall, and one short ton of agricultural gypsum.* As noted above, "virgin" drywall in fact includes some recycled material. Emissions from production of virgin drywall were calculated using the data sources and methodology similar to those used for calculating the source reduction factor. EPA applied fuel-specific carbon coefficients to the process and transportation energy use data for virgin RMAM of drywall (using data from Venta (1997) and Master (2010)).

Because the analysis models both an open- and a closed-loop pathway, EPA also calculates the emissions associated with virgin agricultural gypsum. To do so, EPA uses the same raw material extraction and initial processing energy data used by Venta (1997). Because the more energy-intensive processing of wallboard manufacturing is not necessary, the energy needs of agricultural gypsum are notably less than those of drywall. Transportation estimates of the virgin gypsum were calculated using information from Master (2010).

Exhibit 13: Raw Material Acquisition and Manufacturing Emission Factor for Virgin Production of Agricultural Gypsum ($MTCO_2E$/Short Ton)

(a) Material/Product	(b) Process Energy	(c) Transportation Energy	(d) Process Non-Energy	(e) Net Emissions (e = b + c + d)
Agricultural Gypsum	0.00	0.01	–	0.01

– = Zero emissions.

Step 2: *Calculate emissions for recycled production of drywall and agricultural gypsum.* EPA applied the same fuel-specific carbon coefficients to the process energy required to recycle drywall. EPA obtained information on gypsum recycling from WRAP (2008), which estimates that recycling one metric ton of waste wallboard requires 9.9 kWh of electricity and 0.09 liters of diesel. Because these estimates represent data from the United Kingdom, where renovation/demolition waste drywall is more commonly recycled than in the United States, these estimates reflect a small amount of post-construction wallboard recycling. Because this type of recycling would require additional processing, these estimates may slightly overstate the energy requirements to recycle construction waste drywall. Process energy emissions are shown in Exhibit 14.

While Venta (1997) does include a small amount of recycled gypsum in its calculations, EPA could not disaggregate the data into recycled gypsum and non-recycled gypsum components. Therefore, EPA assumes that recycling displaces all raw material acquisition of gypsum as estimated by Venta (1997), which includes acquisition of some recycled and synthetic gypsum.

EPA did not locate published estimates on transportation distances for transporting reclaimed wallboard to a recycling facility or transporting the recycled gypsum to either the drywall manufacturing facility or the agricultural site. However, recycling facilities tend to deal more locally in terms of both their supply of recycled drywall and also their end-use customers; thus, recycled gypsum generally travels less distance than mined gypsum. EPA uses the U.S. Census Bureau's (2004) estimate on finished drywall transportation for both transporting the waste wallboard to the recycling facility as well as transporting the recycled gypsum to the wallboard manufacturers; the latter seems generally consistent with information provided by Manning (2009) on where one recycler tends to ship its gypsum. We also used Census Bureau (2004) estimates to represent the distance that recycled gypsum is shipped for agricultural purposes. Process energy emissions are shown in Exhibit 15.

Exhibit 14: Process Energy GHG Emissions Calculations for Recycled Production

Product/Material	Process Energy per Short Ton Made from Recycled Inputs (Million Btu)	Energy Emissions ($MTCO_2E$/Short Ton)
Drywall	3.19	0.18
Agricultural Gypsum	0.12	0.01

Exhibit 15: Transportation Energy GHG Emissions Calculations for Recycled Production

Product/Material	Transportation Energy per Ton Made from Recycled Inputs (Million Btu)	Transportation Emissions ($MTCO_2E$/Short Ton)
Drywall	0.02	0.00
Agricultural Gypsum	–	–

Note: The transportation energy and emissions in this exhibit do not include retail transportation, which is presented separately in Exhibit 6.

Step 3: *Calculate the difference in emissions between virgin and recycled production of drywall, and virgin and recycled production of agricultural gypsum.* To calculate the GHG emissions savings from recycling one short ton of drywall, WARM subtracts the recycled product emissions (from Step 2) from the virgin product emissions (from Step 1) for drywall, and for agricultural gypsum.

Step 4: Adjust the emissions differences to account for recycling losses. Material losses occur in both the recovery and manufacturing stages of recycling. The loss rate represents the percentage of end-of-life drywall collected for recycling that is lost during the recycling process, and ultimately disposed of. WARM assumes a 0.2 percent loss rate for drywall recycling (WRAP, 2008). The differences in emissions from virgin versus recycled process energy and transportation energy are adjusted to account for loss rates by multiplying the final three columns of Exhibit 16 by 99.8 percent, the amount of material retained after losses (i.e., 100 percent input – 0.2 percent lost = 99.8 percent retained).

Exhibit 16: Differences in Emissions between Recycled and Virgin Manufacture ($MTCO_2E$/Short Ton)

Product/ Material	Product Manufacture Using 100% Virgin Inputs ($MTCO_2E$/Short Ton)			Product Manufacture Using 100% Recycled Inputs ($MTCO_2E$/Short Ton)			Difference Between Recycled and Virgin Manufacture ($MTCO_2E$/Short Ton)		
	Process Energy	Transpor-tation Energy	Process Non-Energy	Process Energy	Transpor-tation Energy	Process Non-Energy	Process Energy	Transpor-tation Energy	Process Non-Energy
Drywall	0.18	0.04	–	0.19	0.00	NA	0.01	-0.01	NA
Agricultural Gypsum	0.00	0.01	NA	0.01	–	NA	0.01	-0.01	NA

NA = Not applicable.

Step 5: *Develop a weighted recycling factor to reflect the end-use products' respective share of the recycled gypsum market.* The differences in emissions from virgin versus recycled manufacturing of drywall are combined with the differences in emissions from virgin versus recycled manufacturing of agricultural gypsum, weighting the two end uses by their market share. WARM assumes that 19 percent of recycled drywall is recycled into new drywall, and 81 percent is recycled for agricultural purposes (derived from Master, 2009).

4.3 COMPOSTING

Some composting facilities accept clean (e.g., construction scrap) drywall, although most do not accept demolition or renovation waste drywall due to contamination concerns. However, although drywall is accepted at composting facilities, it is misleading to say that it is actually composted.

Drywall is composed primarily of gypsum, which is an inorganic substance and therefore cannot become compost. Instead, drywall is generally added to the compost mix *after* the compost has been created. It is added to compost because gypsum can supply important nutrients to plants. When drywall is sent to a composting facility, therefore, it is actually used as an *additive to* compost, rather than turned *into* compost. More information about drywall recycling can be found at www.drywallrecycling.org.

For these reasons, WARM does not include a composting emission factor for drywall. However, users interested in the GHG implications of sending drywall to a composting facility rather than a landfill may use the drywall recycling factor as a reasonable proxy. The recycling factor is based on the assumption that nearly 81 percent of drywall is recycled into agricultural gypsum, much of which is used as a soil amendment (the other 19 percent is assumed to be recycled into new drywall). Therefore, the recycling factor captures many of the same GHG emissions, and avoided GHG emissions, that would occur if the drywall were sent to a composting facility rather than landfilled. Please note that inherent in the recycling factor is the assumption that the recycled drywall replaces virgin gypsum used as a soil amendment; WARM does not estimate the GHG implications of using recycled drywall instead of other non-gypsum alternatives.

4.4 COMBUSTION

Drywall is generally not combusted, and is even banned from combustion facilities in some states. EPA therefore did not develop an emission factor for combustion.

4.5 LANDFILLING

Landfill emissions in WARM include landfill methane and carbon dioxide from transportation and landfill equipment. WARM also accounts for landfill carbon storage, and avoided utility emissions from landfill gas-to-energy recovery. Because gypsum is inorganic and does not contain biogenic carbon, there are zero emissions from landfill methane, zero landfill carbon storage and zero avoided utility emissions associated with landfilling gypsum. However, the paper facing on drywall is organic, resulting in some landfill methane emissions and carbon sequestration. Because C&D landfills generally do not have flaring systems, most of that methane is released to the atmosphere. EPA obtained data on the moisture content, carbon storage factor and methane yield of drywall from Barlaz and Staley (2009). In addition to those emissions, we assume the standard WARM landfilling emissions related to transportation and equipment use. The methane and transportation emissions outweigh the carbon sequestration benefits, resulting in net emissions from the landfill, as illustrated in Exhibit 17. For more information, please see the chapter on Landfilling.

Exhibit 17: Landfilling Emission Factor for Drywall ($MTCO_2E$/Short Ton)

Material	Raw Material Acquisition and Manufacturing (Current Mix of Inputs)	Transportation to Landfill	Landfill CH_4	Avoided CO_2 Emissions from Energy Recovery	Landfill Carbon Storage	Net Emissions (Post-Consumer)
Drywall	–	0.04	0.18	–	-0.09	0.13

– = Zero emissions.

5. LIMITATIONS

Although this analysis is based upon best available life-cycle data, the primary data source for this material (Venta) was published in 1997. Although EPA made some updates to the dataset, most of the calculations rely on data that are now more than 10 years old, and that reflect the Canadian drywall industry. Meanwhile, data on energy needs for recycling came from WRAP (2008), which relies on an analysis of the drywall industry in the United Kingdom. Advancements in production processes, and industry differences among nations, could affect the resulting emission factors.

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